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U.h.f. relay stations:

vertically-polarized printed panel aerial

No. 1970/17

Research Department, Engineering Division
THE BRITISH BROADCASTING CORPORATION

RESEARCH DEPARTMENT

U.H.F. RELAY STATIONS: VERTICALLY-POLARIZED PRINTED PANEL AERIAL

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G.H. Millard, B.Sc., A.Inst.P.

D. Maurice
Head of Research Department

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U.H.F. RELAY STATIONS: VERTICALLY-POLARIZED PRINTED PANEL AERIAL

SUMMARY

A vertically-polarized panel aerial has been designed in order to satisfy a variety of directional requirements at low-power u.h.f. relay stations. The aerial uses printed circuit techniques for cheapness and accuracy of reproduction.

1. INTRODUCTION

The majority of u.h.f. relay stations now in service utilise transmitting aerials having a cardioidal horizontal radiation pattern (h.r.p.).[1] At a few stations a more directional h.r.p. has been required and an aerial normally used for reception[2] has been adapted for transmission. As more low-power relay stations are required it is expected that the number of directional aerials will increase, partly to concentrate the available power where it is needed but more especially to minimise co-channel interference to other areas using the same channel allocations. The exact form of the directional requirement will vary from station to station so that it will be advantageous to use a basic aerial unit (panel), numbers of which may be assembled in different configurations.

The smallest aerials planned will have a vertical length of four wavelengths and since it is normal practice to feed each half aerial separately to give reserve facilities, each panel should have a radiating length of two wavelengths.

It is also desirable that each panel should have a satisfactory impedance and radiation pattern over a wide band of frequencies, not only to permit four-channel operation but also to minimize the number of versions of the aerial required to cover the u.h.f. television bands.

2. CONSTRUCTION OF PANEL

The panel comprises two 'batwing' elements spaced approximately one wavelength from each other and about one quarter wavelength from a reflecting screen. (Fig. 1). Each radiating element is driven through a 100 ohm distribution feeder and a Pawsey stub balun and the distribution feeders are paralleled to give a 50 ohm input impedance. The 'batwing' elements and the associated feed connections are printed on 1·6 mm (1/16 in.) glass fibre laminate.

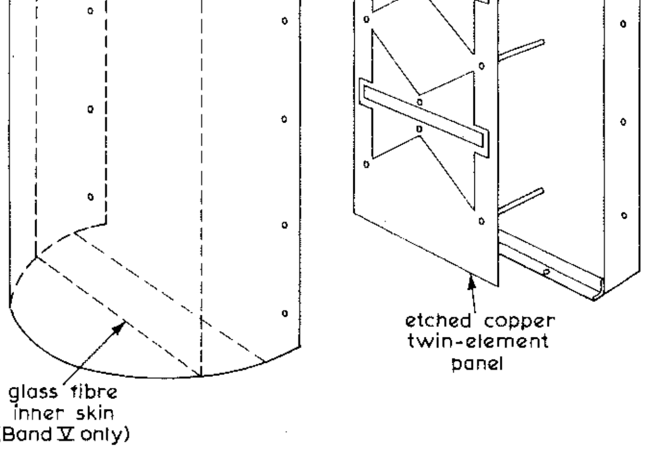

Fig. 1 - Twin-element batwing aerial panel and cover

Details of the feeding arrangement are shown in Fig. 2. The radiating elements are protected from the weather and from accidental mechanical damage by means of a glass fibre cover. In the case of the Band V panel only, the electrical effect of the glass fibre cover is reduced by means of an inner skin.

Two models of the panel were made, covering Band IV (470 MHz – 582 MHz) and Band V (614 MHz – 854 MHz) respectively.

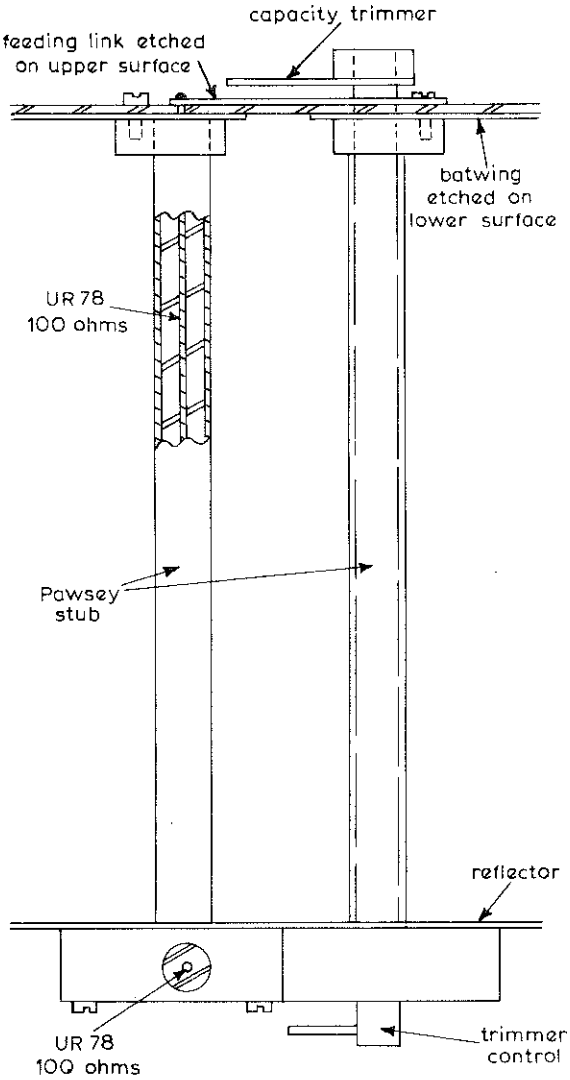

Fig. 2 - Detail of feed arrangement

3. ADMITTANCE

At a typical station with a mean aerial height of about 36 m (120 ft), the relative amplitude of radiated delayed signal (resulting from mismatch at the transmitting aerial) should be arranged to be less than –34 dB.[3] Taking losses in the feeders and combining networks into account and allowing for 10 dB reflection loss at the translator,* the maximum permissible reflection coefficient at the transmitting aerial is 10%. The reflection coefficient achieved on the complete aerial will be dependent on the distribution

* It is hoped that a more typical figure may prove to be 15 dB, but at the present time this is not assured.

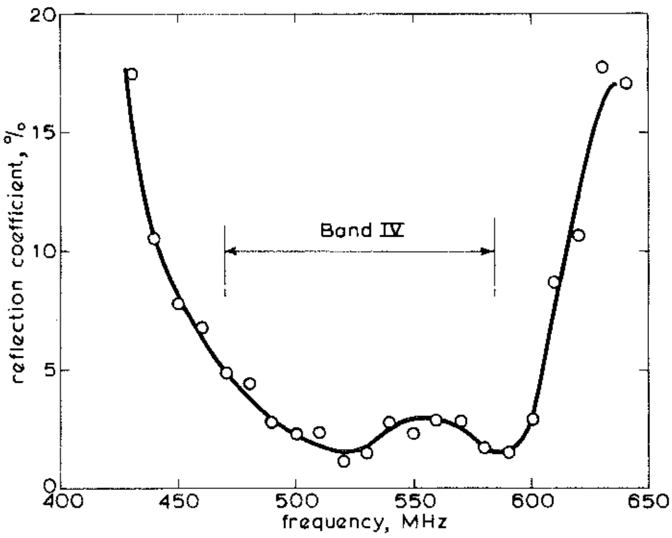

Fig. 3 - Measured reflection coefficient of Band IV aerial panel

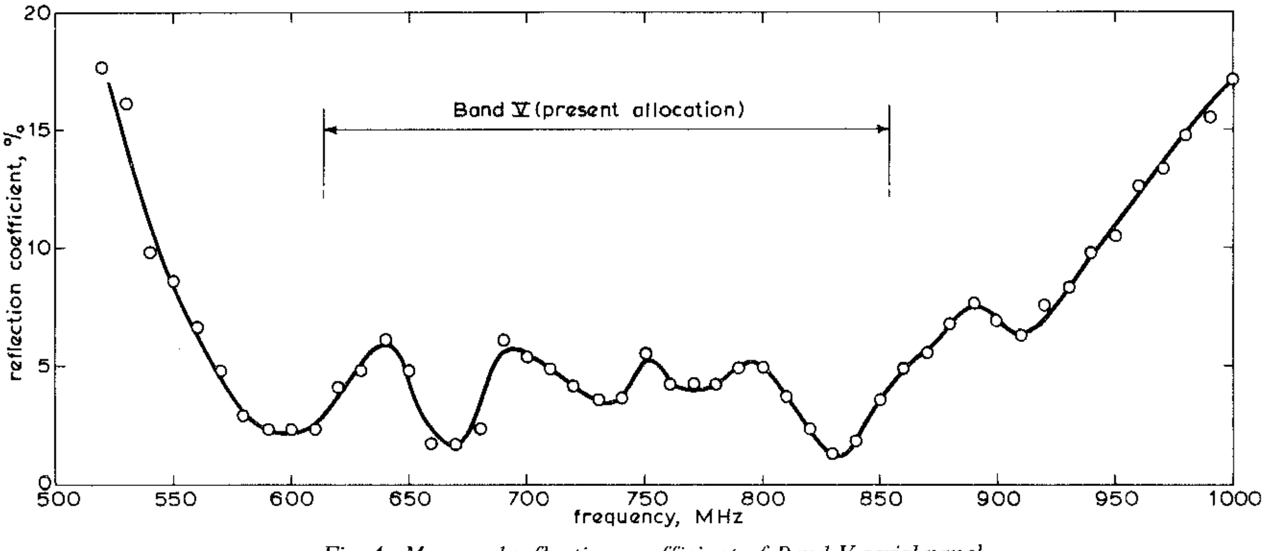

Fig. 4 - Measured reflection coefficient of Band V aerial panel

transformers, the aerial panels and whether the latter are driven in phase or phase quadrature etc. On the simpler arrangements of panels it may not be possible to use phase quadrature arrangements and it is therefore desirable that the reflection coefficient of a single panel should be appreciably less than 10%. The level achieved was of the order of 6% over the working frequency band for both panels. Figs. 3 and 4 give the variation of reflection coefficient as a function of frequency for the Band IV and Band V panels respectively.

4. HORIZONTAL RADIATION PATTERNS

The h.r.p.s of the Band IV and Band V panels are shown in Figs. 5 and 6 respectively. The beamwidth between half-power points lies in the range 55° – 70° and this is sufficiently wide to enable a single panel per tier to be used for many stations. Where the area to be served subtends a greater arc than this, combinations of two or more panels may be used. Figs. 7 and 8 show the h.r.p.s obtainable with two panels mounted at 90° and Figs. 9 and 10 the

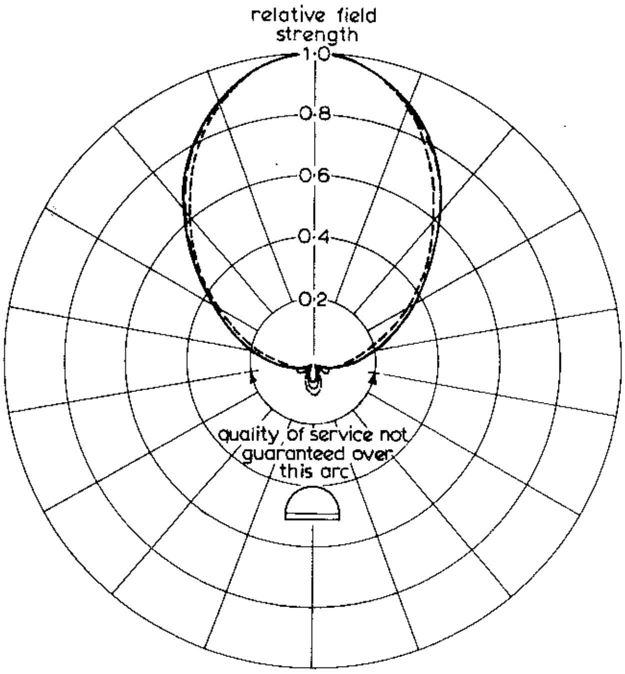

Fig. 5 - H.R.P. of single Band IV aerial panel

— — — 450 MHz ——— 530 MHz - - - - - - 600 MHz

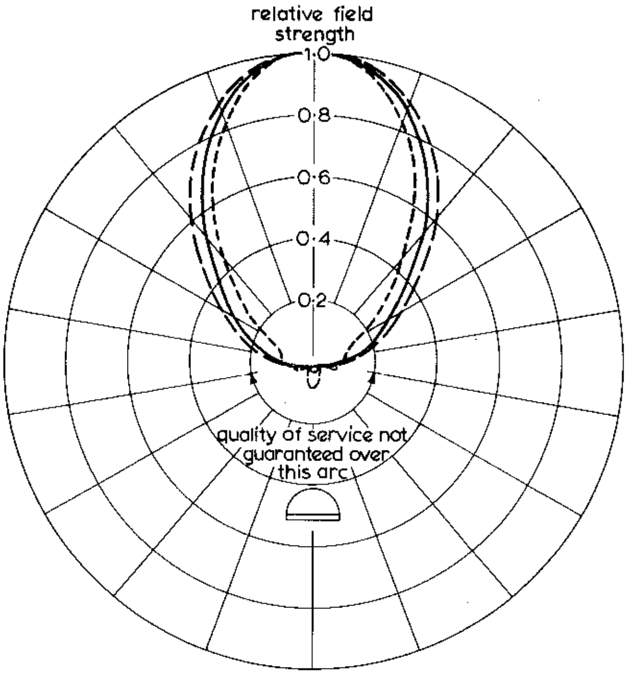

Fig. 6 - H.R.P. of single Band V aerial panel

— — — 600 MHz ——— 750 MHz - - - - - - - 860 MHz

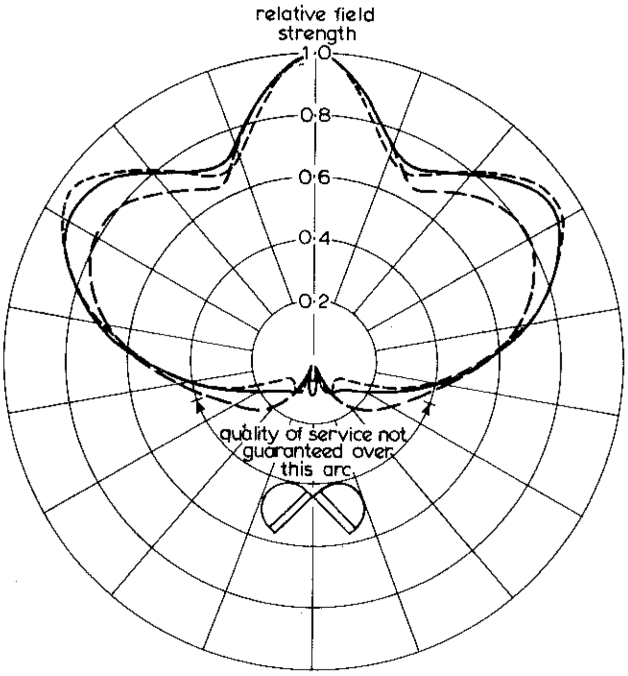

Fig. 7 - H.R.P. of two Band IV aerial panels set at 90°

— — — 450 MHz ——— 530 MHz - - - - - - - 600 MHz

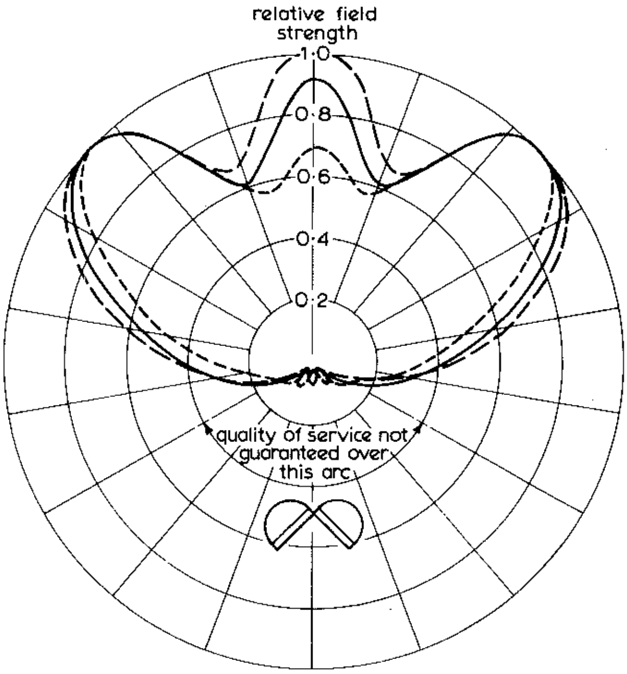

Fig. 8 - H.R.P. of two Band V aerial panels set at 90°

— — — 600 MHz ——— 720 MHz - - - - - - - 860 MHz

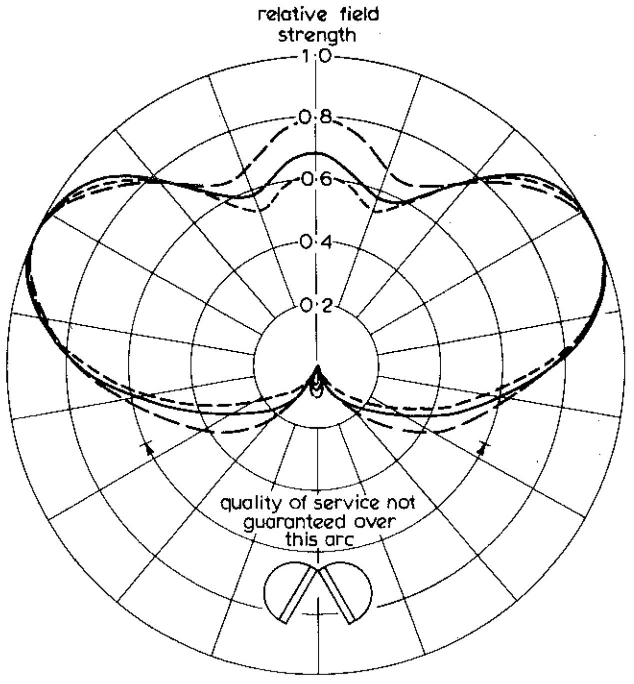

Fig. 9 - H.R.P. of two Band IV aerial panels set at 120°

— — — 450 MHz ——— 530 MHz - - - - - - 600 MHz

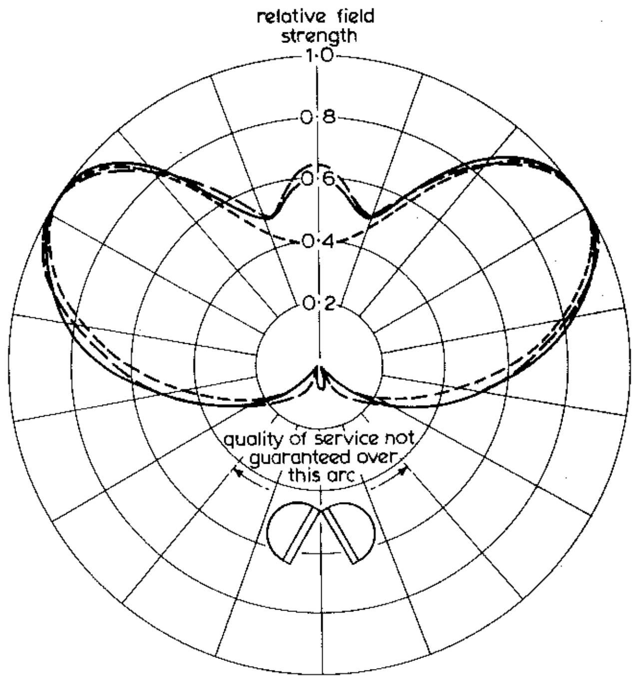

Fig. 10 - H.R.P. of two Band V aerial panels set at 120°

—·—·— 600 MHz ——— 720 MHz - - - - - - 860 MHz

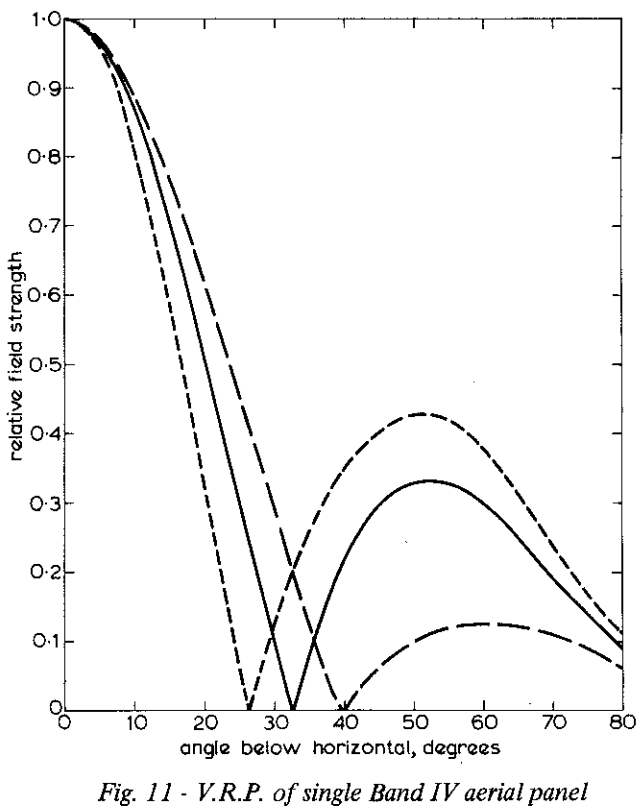

Fig. 11 - V.R.P. of single Band IV aerial panel

— — — 450 MHz ——— 530 MHz - - - - - - 600 MHz

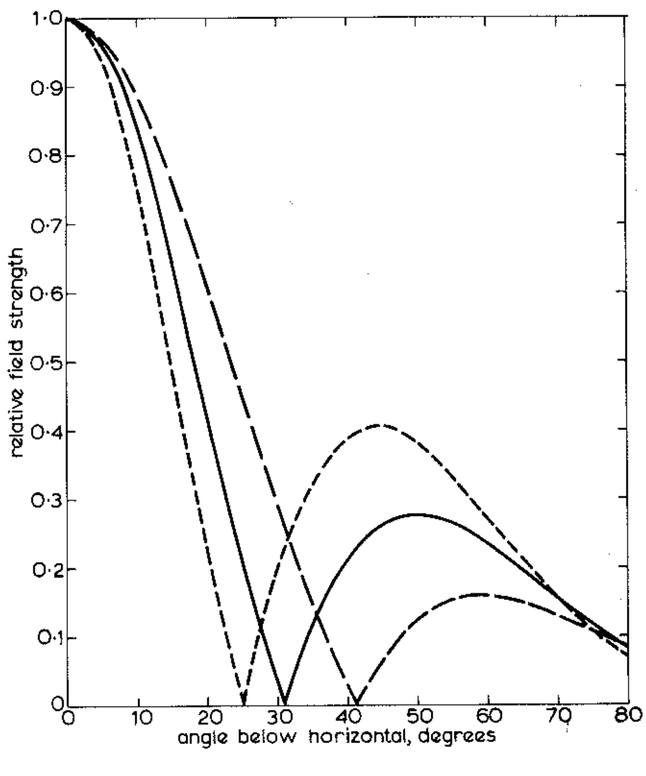

Fig. 12 - V.R.P. of single Band V aerial panel

— — — 600 MHz ——— 750 MHz - - - - - - 860 MHz

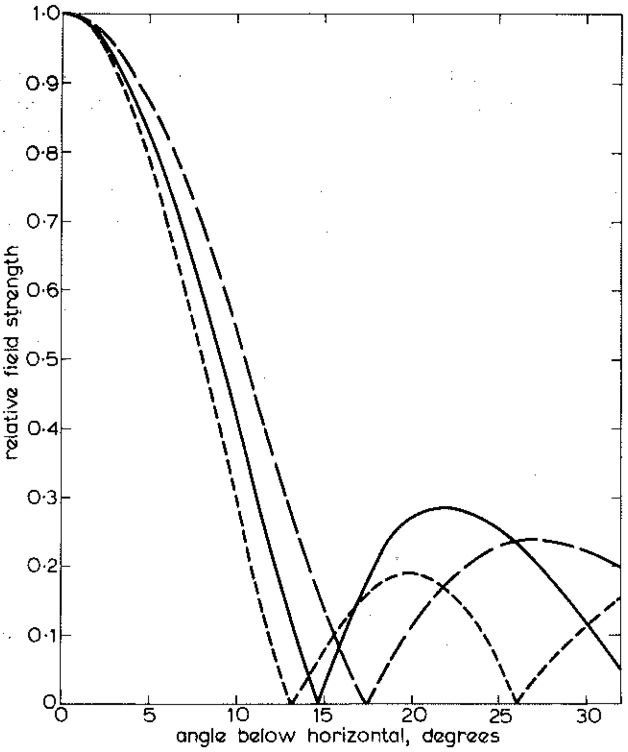

Fig. 13 - V.R.P. of two stacked Band IV aerial panels

——— 450 MHz ——— 530 MHz - - - - - 600 MHz

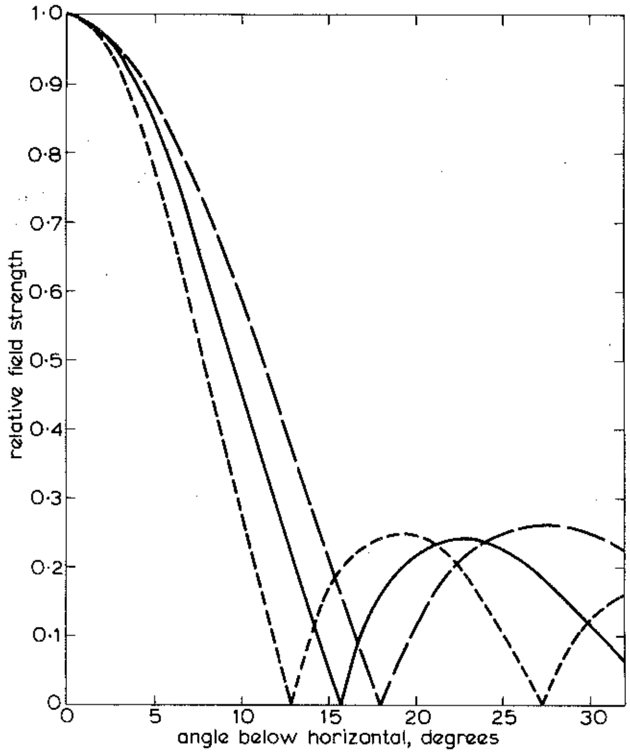

Fig. 14 - V.R.P. of two stacked Band V aerial panels

——— 600 MHz ——— 750 MHz - - - - - 860 MHz

h.r.p.s with two panels mounted at 120°. Since these h.r.p.s are highly directional, there are arcs in the vicinity of the minima where unacceptable differences between channels may arise; these arcs are shown on each figure.

5. VERTICAL RADIATION PATTERN (V.R.P.)

The v.r.p.s of the individual panels are shown in Figs. 11 and 12, and those of two panels stacked vertically (giving a vertical length of 4λ) are shown in Figs. 13 and 14.

At some stations it will be desirable to tilt the maximum of the v.r.p. below the horizontal. This could be effected by tilting the panels physically. However, provided that the angle of tilt is small ($\leqslant 6°$, say) it will probably be more convenient to tilt the beam electrically by retarding the phase of the feed to the lower panel.

At a few stations it may be necessary to fill the first minimum of the two stack v.r.p. Although this could be done by physically tilting the upper and lower panels in opposite directions, it may be more convenient to feed unequal powers to the half aerials.

It is probable that aerials of greater radiating length will be required for some stations but no special difficulties are expected.

6. GAIN

Gains were deduced by integration of the radiation patterns and take into account losses in the UR78 distribution feeder. The gains of single panels in the direction of maximum radiation are given in Table 1, relative to a half-wave dipole.

TABLE 1

Gain of Single Panel

Band IV Panel		Band V Panel	
450 MHz	9·6 dB	600 MHz	9·9 dB
530 MHz	9·7 dB	750 MHz	10·9 dB
600 MHz	10·3 dB	860 MHz	11·8 dB

In practice, not less than two tiers of panels will be used. Gains of two tiers with arrangements of one or two panels in each tier are given in Table 2; they refer to the maximum of the h.r.p. and are relative to a half-wave dipole.

TABLE 2

Gains of Arrangements of Two Tiers of Panels

Arrangement	Band IV Panels			Band V Panels		
	450 MHz	530 MHz	600 MHz	600 MHz	750 MHz	860 MHz
1 Panel per tier	12·8 dB	13·0 dB	13·3 dB	12·6 dB	13·7 dB	14·7 dB
2 Panels per tier, set at 90°	10·9 dB	10·7 dB	10·8 dB	10·1 dB	11·3 dB	12·4 dB
2 Panels per tier, set at 120°	10·0 dB	10·3 dB	10·5 dB	9·6 dB	10·9 dB	12·1 dB

7. POWER RATING

The parts of the panel which seemed likely to determine the power rating were the printed connection at the drive point, the UR78 distribution feeders and the input connector. The distribution feeders are rated at 195 W mean at 850 MHz for an ambient temperature of 40°C, giving a limit for one panel of 390 W mean. The input connector to the panel may be safely used up to about 400 W at 850 MHz. Thus, provided the feed-point connection does not overheat, the Band V panel should have a power rating of 390 W mean at 850 MHz; the corresponding figure for the Band IV panel at 580 MHz is 490 W mean.

Power tests were carried out on one panel of each type. The Band IV panel was tested at a level of 600 W at a frequency of 545 MHz in an ambient temperature of 15°C and for a short period at 1 kW. The Band V panel was tested at a level of 300 W at a frequency of 750 MHz in an ambient temperature of 20°C, this being the highest power available. These tests confirmed that the power rating is determined by the distribution feeder.

The above limits indicate that an aerial comprising two or more panels will be well within rating when used with translator powers of 10 W and 50 W peak vision. Should it ever be desired to use an aerial comprising only two panels with powers of 200 W peak vision, this will still be possible, with full reserve facilities, (i.e. capable of taking all the power in one panel under emergency conditions), provided feeder and network losses totalling 2·3 dB are present.

8. CONCLUSIONS

Two vertically polarized aerial panels have been designed, one for Band IV and one for Band V. The Band V version covers a frequency range of 1·55 : 1 with a reflection coefficient not exceeding 6%. In the Band IV version some of the inherent bandwidth has been sacrificed in order to make the panel smaller, but the reflection coefficient does not exceed 5% over the required frequency range.

By assembling numbers of the panels in various configurations, it will be possible to satisfy most directional aerial requirements at low-power u.h.f. relay stations.

9. REFERENCES

1. A vertically-polarized transmitting aerial for u.h.f. relay stations. BBC Research Department Report No. E-122, Serial No. 1966/74.
2. A u.h.f. trough aerial for re-broadcast reception. BBC Research Department Technical Memorandum No. RA-1019.
3. Specification of the impedance of transmitting aerials for monochrome and colour television signals. BBC Research Department Report No. E-115, Serial No. 1965/8.

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